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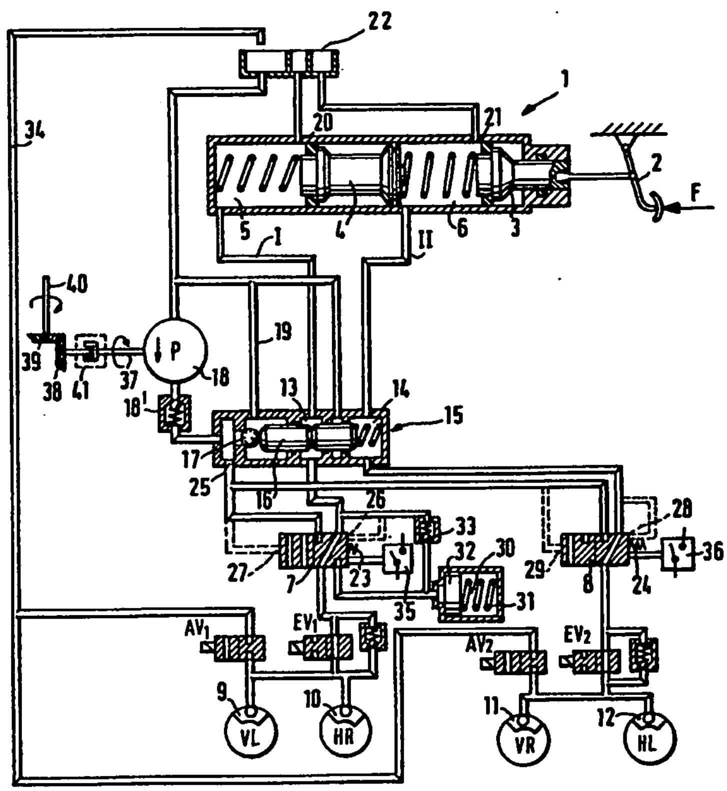
(54) **Hydraulic brake system for motor vehicles**

(57) A brake system with hydraulic brake force boosting is comprised by a braking pressure generator (1) formed as a pedal-actuated master cylinder connected to which, via pressure-controlled multi-directional valves (7, 8), are wheel brakes (9 to 12). Moreover, an auxiliary-pressure supply system is provided which comprises a braking pressure control valve (15) and an hydraulic pump (18). The braking pressure generator (1) controls the auxiliary pressure. Upon applying the brakes, the switch-over of the multi-directional valves (7, 8), controlled auxiliary pressure in place of the pressure generated in the braking pressure generator 1, is applied to the wheel brakes (9 to 12).

The hydraulic pump 18, directly or indirectly or via the motor vehicle whe ls, is actuated by th vehicle driving motor. Alternatively, the hydraulic pump (18), via a spe dometer shaft conn ction (41) is coupl d to the vehicl diff r ntial.

A system of the afore-described type can be extended to a slip-controlled brake system by the insertion of inlet and outlet valves (EV, AV).



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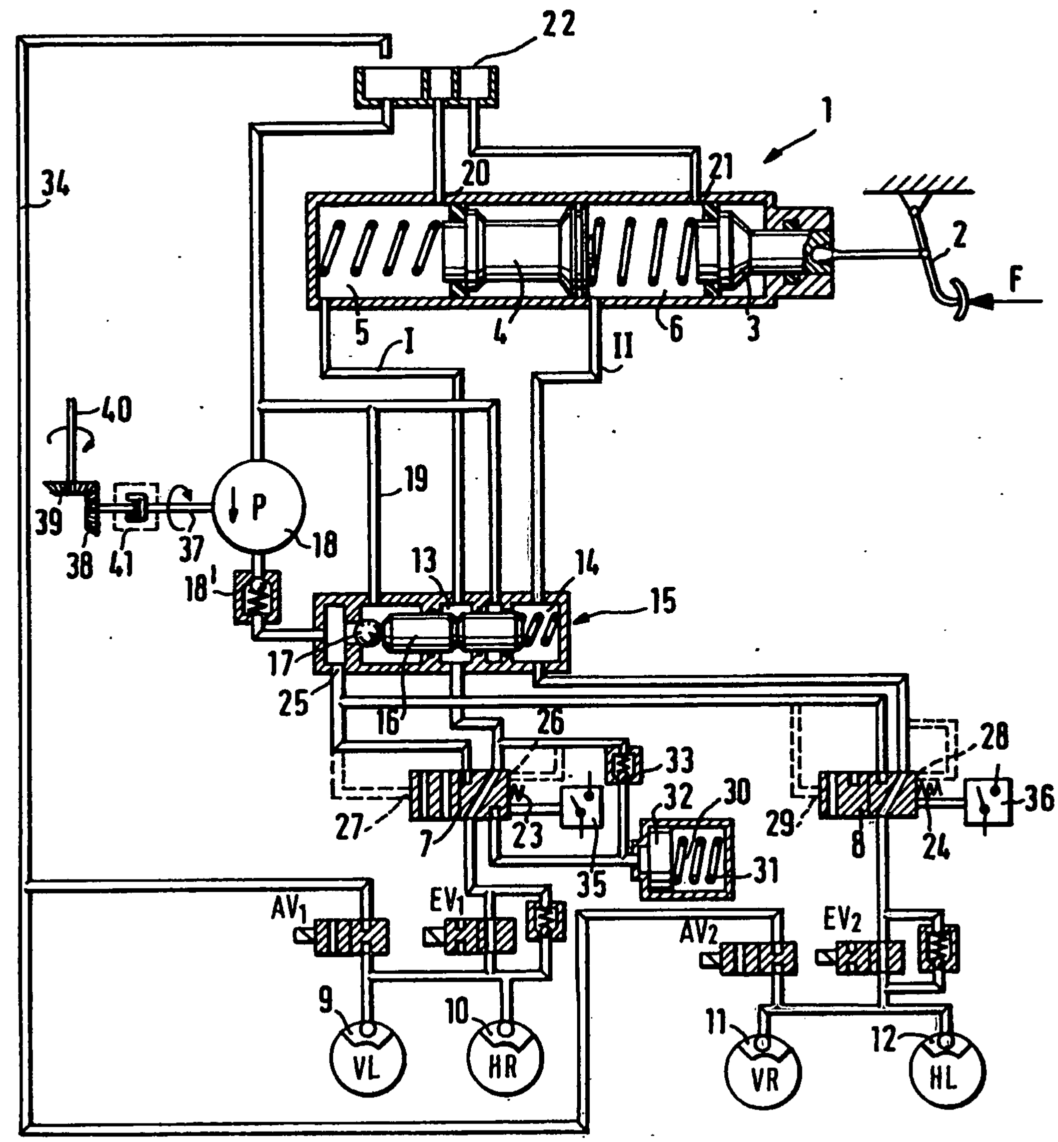
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AV1
EV1
AV2
EV2
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VL
HR
VR
HL

SPECIFICATION

Hydraulic brake system for motor vehicles

This invention relates to an hydraulic brake system for motor vehicles, comprised by a pedal-actuated braking pressure generator connected to which, via pressure fluid lines, are wheel brakes; an auxiliary-pressure supply system comprising an auxiliary-pressure source and an auxiliary-presure control valve which causes an auxiliary pressure proportional to the applied pedal force; and pressure-controlled multi-directional valves inserted into the pressure fluid lines between the braking pressure generator and the wheel brakes, which multi-directional valves in their inactive or initial position, provide an hydraulic connection between the braking pressure generator and the wheel brakes and which, after change-over into a second switch position, connect the auxiliary-pressure control valve instead of the braking pressure generator to the pressure fluid lines leading to the wheel brakes.

Conventional brake systems of this type having a hydraulic brake force booster consist of a single-type or tandem-type master cylinder with a hydraulic brake force booster connected upstream thereof. To provide the auxiliary pressure, a hydraulic pump actuated by electromotive force and a hydraulic accumulator are included in the system. The brake force booster comprises an auxiliary-pressure control valve which upon actuation of the brake pedal causes an auxiliary pressure proportional to the pedal force, which acts on the pistons in the master cylinder. The boosting factor of the brake system is determined by the ratio of the surfaces of a transmission piston in the interior of the brake force booster in relation to the surface of an actuating piston mechanically coupled to the brake pedal. As the brake circuits connected to the master cylinder are designed as static circuits, the volume of the pressure chambers in the master cylinder must be adapted to the respective brake system.

West German Offenlegungsschrifts Nos. DE-OS 30 40 561 and DE-OS 30 40 562 describe skid-controlled brake systems also comprising a master cylinder including an hydraulic brake force booster connected upstream thereof, and an hydraulic pump along with an hydraulic accumulator for the auxiliary pressure supply. For the skid control, electromagn tically operable valves are insert d into the pressure fluid lin s leading to th wh el brakes, by way of which the pr ssur fluid lin from the mast r cylinder to the wh el brakes can be blocked and, for the pressure build-up, a return-flow line for the pressure fluid from the wheel brake to a pressure compensation reservoir, can be opened. During the skid control, with the aid of the brake force booster, controlled dynamic pr ssur is introduced via another valve into the brake circuits connected to the master cylinder which, pending commencement of the slip control, are also static, to preclude emptying of the brake circuits and to replace, respectively, the pressure fluid discharged during the pressure decreasing phase into the compensating reservoir. Moreover, in such multi-circuit brake systems, a brake circuit can be directly connected to the brake force booster and, hence, be actuated dynamically. Systems of this type are rather complex and costly.

In our co-pending GB Application No. 8600550 (Serial No.) there is described a brake system in which the master cylinder—with the brake system intact—in the first place serves to control the auxiliary pressure. For that purpose, a hydraulic pump driven by electromotive force and actuated upon application of the brakes, and an auxiliary-pressure control valve are provided which are capable of generating an auxiliary pressure proportional to the pressure in the master cylinder circuits and, hence, proportional to the applied pedal force. Via pressure-controlled multidirectional valves, upon each application of the brakes, the auxiliary-pressure source, in place of the master cylinder, is connected to the wheel brakes. Upon failure of the auxiliary-pressure supply, the multi-directional valves take their inactive position in which the master cylinder brake circuits are connected to the wheel brakes. In this manner, a particularly simple and reliable brake system can be realised which can also be extended to a slip-controlled system because the brake circuits are of a dynamical configuration; the pressure fluid flowing off during the pressure decreasing phase, is directly reloaded via the hydraulic pump.

It is, therefore, an object of the present invention, to reduce the manufacturing efforts involved with a brake system of the type described in the co-pending application, with no loss in serviceability and reliability of the system.

According to the present invention there is provided an hydraulic brake system in a motor vehicle, which brake system is comprised by a pedal-actuated braking pressure generator connected to which, via pressure fluid lines, are wheel brakes; an auxiliary-pressure supply system comprising an auxiliary-pressure source and an auxiliary-pressure control valve which causes an auxiliary pressure proportional to the appli d p dal forc , and pr ssure-controll d multi-dir ctional valves inserted into the pressur fluid lin s between the braking pressure g nerator and the wh el brakes, which valves, in their inactive or initial position, provide an hydraulic conn ction betwe n th braking pressure generator and th wheel brakes and which, aft r change-over into a second switching position, connect the auxiliary-pressur control valve instead of the

braking pressur generator to the pressure fluid lines leading to the wh el brakes, characterised in that the auxiliary pressure source is an hydraulic pump actuated directly or indirectly by the vehicle engine or via the vehicle wheels.

According to an advantageous form of embodiment of the invention, the hydraulic pump, via a speedometer shaft connection, seated, for example, on the master shaft of the vehicle's differential, is coupled to the motor vehicle wheels.

Conversely, it is also possible to connect the hydraulic pump in force-locking manner, via a gear or a V-belt, to the driving shaft of the vehicle engine, for example, to the crankshaft of a reciprocating engine.

A special form of embodiment of the invention which, in some cases may be advantageous, resides in that the hydraulic pump is furnished with an additional drive which is comparatively weak and, hence, can be manufactured with relatively low efforts, which is capable of generating the hydraulic auxiliary pressure required for stopping the motor vehicle on a sloping lane or for decelerating the vehicle out of a low speed.

In the practice of the invention, hence, provision of a separate electromotor for driving the hydraulic pump is foregone and, in place, the said pump is connected to the driving motor or—via the differential—to the driven wheels, thereby safeguarding that during deceleration from a high speed the required high auxiliary energy and a high auxiliary pressure, respectively, be available, whereas for stopping the motor vehicle or for decelerating same from a low speed, respectively, a comparatively low brake pressure will be adequate which is supplied by the pump also at a low speed or which, if need be, can be directly generated by the pedal-operated master cylinder.

Foregoing the provision of a special driving motor for the hydraulic pump, moreover, results in an increased reliability of the brake system because the d.c. motors which can be employed for actuating such pumps, as compared with the hydraulic components, are more susceptible to problems.

An embodiment of the invention will now be described with reference to the accompanying partially schematic and partially sectioned drawing.

The brake system as shown in the drawing compris s a tandem master cylinder serving as the braking pressure generator 1. Th pedal forc F, via a brake pedal 2, is applied to the push rod piston 3 and the interm diate piston 4 of the master cylind r. Hydraulically operable whe l brakes 9 to 12 are connected to the two working chamb rs 5, 6 of th mast r cylind r via two hydraulically separated pressure fluid circuits I, II, via pressure-controll d multi-directional valv s 7, 8 and via electromagnetically switchable inlet valv s EV_1, EV_2. In the example of embodiment as presently described, brake circuits I, II are diagonally split. Brake circuit I leads to the left-hand front wheel VL and to the right-hand rear wheel HR, while brake circuit II leads to the two other wheels VR, HL.

Moreover, the two control chambers 13, 14 of an auxiliary-pressure control valve generally designated by reference numeral 15, are connected to the working chamber 5, 6. The said control pressure, via a split control piston 16 in the interior of the valve 15, is applied to a spherical seat valve 17 which, in turn, is inserted into the pressure fluid line leading from the pressure side of an hydraulic pump 18, via the associated non-return valve 18' and via a line 19 to the intake side of the pump, and which determines the level of the controlled auxiliary pressure in response to the pressure prevailing in the control chambers 13, 14.

The intake side of the pump 18 communicates - as do breather bores 20,21 of the master cylinder 1, which are traversed upon application of the brakes—with a pressure compensating and pressure fluid supply reservoir 22.

Valves 7, 8 are configured as double pressure-controlled multi-directional valves capable of taking two positions. In the initial or rest position, the two valves are in the switch position as shown, in which they establish a connection between the braking pressure generator 1 and the wheel brakes 9 to 12. Restoring springs 23, 24 safeguard that the said switching position is maintained with non-pressurised control inlets or in a pressure equilibrium state.

The pressure generated in the braking pressure generator 1 and the controlled auxiliary pressure prevailing at a pressure fluid connection 25 on the auxiliary-pressure control valve 15, via inlets 26, 27 and 28, 29, respectively, act upon the valves 7, 8 in opposite actuating directions.

Valve 8 is configured as a three-way/two-position multi-directional valve connecting either the brake circuit II of the braking pressure generator 1 or the auxiliary pressure source, i.e. the controlled auxiliary pressure applied to connection 25 of control valve 15, to wheel brakes 11, 12. The same applies, analogously, to the multi-directional valve 7, which, however, is formed as a four-way/two-position multi-directional valve, wherein the additional pressur fluid line aft r switch-over of th valv into th second switching position th r of, connects a pedal travel simulator 30 to brake circuit I of th braking pressur generator 1. In that s cond switching position of valve 7, controlled auxiliary pressure is applied to th wheel brak s 9, 10.

Simulator 30 substantially is composed of a piston 32 displaceable by the hydraulic pr ssure against the force of a restoring spring

31. For restoring the said piston after releasing the brakes, a non-return valve 33 is provided which is capable of opening toward the braking pressure generator 1.

Finally, the brake system as shown is provided, in addition, with outlet valves AV_1, AV_2, via which, for decreasing the braking pressure in the event of imminent locking of a wheel, pressure fluid can flow off via the return line 34 toward the compensating reservoir 22. The inlet and outlet valves EV_1, EV_2, AV_1, AV_2 are required for the skid control only.

The switching position of valves 7, 8 can be signalled via mechanical or electronic switches 35, 36 as symbolically shown. A pressure failure in the auxiliary pressure supply system or in a brake circuit I, II of the braking pressure generator is revealed by the switching position of valves 7, 8. The electrical output signals of the switches 35, 36, possibly, are supplied to a pressure tell-tale (not shown) and/or analysed to render inoperative the slip control after a defective condition having been identified.

The hydraulic pump 18 is actuated by a shaft 37 which, in turn, via gears 38, 39, is in communication with a shaft 40 driven directly or indirectly by the driving motor of the vehicle. A connection of the driving shaft 37 to a shaft of the vehicle compensating gear in permanent engagement with the driving wheels, has proved to be advantageous. During running of the vehicle, in that case with the driving motor even being in the inoperative position, pump 18 is actuated. In a good many vehicles, the driving shaft 37 can be coupled to the speedometer shaft connection 41 of the vehicle, symbolically shown, which involves a minimum of structural efforts.

In one form of embodiment (not shown) of the invention, in addition to the drive of the pump 18, via a shaft 37, a comparatively low-cost, lowcapacity electromotor could be connected by way of which, even with the motor vehicle at a standstill or driving at a very low speed, an auxiliary pressure sufficient for brake force boosting, can be generated. However, with a suitable layout of the braking pressure generator 1 and the vehicle brakes 9 to 12, such an auxiliary drive can be foregone which, as a rule, does not involve a loss of comfort.

The mode of operation of the brake system as described is as follows: Upon commencement of a braking op ration, all valv s ar in the switching position as shown. A minimum pressure pr vails on the outlet of pump 18 becaus th pr ssure side and the intake side of the pump are short-circuited via the opened spherical seat valv 17 and th r turn line 19.

However, after a braking pr ssur build-up on the outlets of the braking pr ssure g nerator 1 and in the braking circuits I, II, respectively, an auxiliary pressure proportional to the pedal force F will build up on the seat of the spherical valve 17 and, hence, on connection 25 thereof, which auxiliary pressure will soon exceed the pressure in the brake circuits I, II. Crucial to the arising pressure ratio is the surface of attack of the pressure on the spherical seat valve 17 in relation to the (larger) pressure attack surface in the control chamber 14; the control chamber 13 will become operative upon failure of the brake circuit II.

As soon as the controlled auxiliary pressure at the valve inlets 27 and 29, respectively, exceeds the master cylinder pressure at the inlets 26 and 28, respectively, a switch-over of the valves 7, 8 occurs. In lieu of the braking pressure generator 1, the outlet 25 of the auxiliary-pressure control valve 15 and, hence, the controlled auxiliary pressure, will be applied to the wheel brakes 9 to 12. After switch-over of the valves 7, 8, only the pedal travel simulator is still in communication with the braking pressure generator 1.

In the event of a failure of the auxiliary-pressure supply system, for example, in the event of malfunction of pump 18, a defective condition in control valve 15 or in the communication conduits or the like, the switching position of valves 7, 8 as shown is maintained or the valves switch back to their inactive position. With the aid of the braking pressure generator 1 configured as the tandem master cylinder, the vehicle, also in that situation, can be decelerated. However, an increased pedal force F will be required because brake force boosting is eliminated. If the defective condition or pressure failure is restricted to one of the two pressure-controlled valves 7, 8, the hydraulic brake force boosting remains operative in the intact circuit and, hence, in a diagonal of the vehicle.

Actuating the hydraulic pump, as suggested by the invention, via the vehicle driving motor or the vehicle wheels, hence, will reduce the number of component parts required for the brake sytem, at the same time attaining an increased reliability. The auxiliary energy available for brake force boosting will increase with a rising speed of the motor vehicle; a characteristic curve of this type is optimum.

CLAIMS

1. An hydraulic brake system in a motor vehicle, which brake system is comprised by a pedal-actuated braking pressure generator connected to which, via pressure fluid lines, are wh l brakes; an auxiliary-pressur supply system comprising an auxiliary-pressure source and an auxiliary-pr ssure control valv which causes an auxiliary pressure proportional to the applied pedal force, and pressure-controlled multi-directional valves inserted into th pressure fluid lines betwe n the braking pr ssure generator and th wheel brakes, which valves, in th ir inactiv or initial position, provid an hydraulic conn ction b tw n th

braking pressure generator and the wheel brakes and which, after change-over into a second switching position, connect the auxiliary-pressure control valve instead of the braking pressure generator to the pressure fluid lines leading to the wheel brakes, characterised in that the auxiliary pressure source is an hydraulic pump (18) actuated directly or indirectly by the vehicle engine or via the vehicle wheels.

2. A brake system according to claim 1, characterised in that the hydraulic pump (18) is coupled to the vehicle wheels via a speedometer shaft connection (41).

3. A brake system according to claim 1, characterised in that the hydraulic pump (18) is coupled to the driving shaft (40) of the vehicle engine, i.e. to the crankshaft in reciprocating engines.

4. A brake system according to any one of claims 1 to 3, characterised in that the hydraulic pump (18) is equipped with an additional drive generating the auxiliary pressure required for stopping the vehicle on a sloping lane or for decelerating it from a low speed.

5. An hydraulic brake system in a motor vehicle substantially as herein described with reference to the accompanying drawing.

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